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PARTHENOGENESIS IN ANIMALS

Parthenogenesis term arised from the combination of two words; a Greek word 'Parthenos' which means 'virgin' and 'gene' which means 'birth' thus parthenogenesis means a virgin birth. From long times, it was known that in certain animals, females can produce eggs capable of development without previous copulation, and was called as 'lucina sine concubitu' that has meaning in English as 'pregnancy without intercourse'. By the time, this term was together used to denote the pregnancy of those ladies who couldn't otherwise explain their pregnancy around 1750. Later on, the term 'parthenogenesis' came into existence in the year 1849 as coined by Richard Owen, who defined it as 'procreation without the immediate influence of a male'. However, this is vague definition and appears to include various processes such as fission and budding in addition to the development of unimpregnated ova. More appropriately it was defined by Suomalainen in 1950 as 'the development of the egg cell into a new individual without fertilization'. The definition put forwarded by Suomalainen holds true in the case of lower animals where viable progenies are produced through this method. However in higher animals, embryos produced show high mortality. Therefore, Beatty defines this process as 'the production of an embryo from a female gamete without the occurrence of a male gamete, and with or without eventual development into an adult' in 1957. However, he again modified his definition in 1967 as 'the production of an embryo from a female gamete without any genetic contribution from a male gamete, and with or without eventual development into an adult' to include gynogenesis where entry of sperm activates the egg but does not contribute genetic material. Thus, parthenogenesis can be defined as *"a biological process in which an egg is developed into an adult without the contribution of genetic material by the male counterpart"*.

It has been observed through the study of paleontological evidences that animals reproduced via parthenogenesis as early as millions of years ago, first emerging in some of the smallest and simplest organisms. However, presence of this type of reproduction in advanced animals propelled the researcher to put forwarded a notion that the ability to reproduce asexually came about as an effort of species facing continuously adverse condition. The parthenogenesis is largely observed in certain insects (Hymenoptera, Homoptera, Coleoptera), crustaceans and rotifers. Some reptiles, such as lizards and rattle snakes also show such type of development. In rotifers and lizards, males are unknown. In honey bee, queens and workers develop from fertilized eggs, while drones, i.e., males develop from unfertilized eggs. In aphids (insects) and water fleas (crustacean), it can occur for several generations, following which males are produced (by chance) and mating occurs.

Types of parthenogenesis

Parthenogenesis may be of two types, natural parthenogenesis and artificial parthenogenesis.

1. **Natural Parthenogenesis:** In certain animals, the parthenogenesis occurs regularly, constantly and naturally in their life cycles. Such occurrence of parthenogenesis is known as natural parthenogenesis. The natural parthenogenesis may be of two types, complete or incomplete.

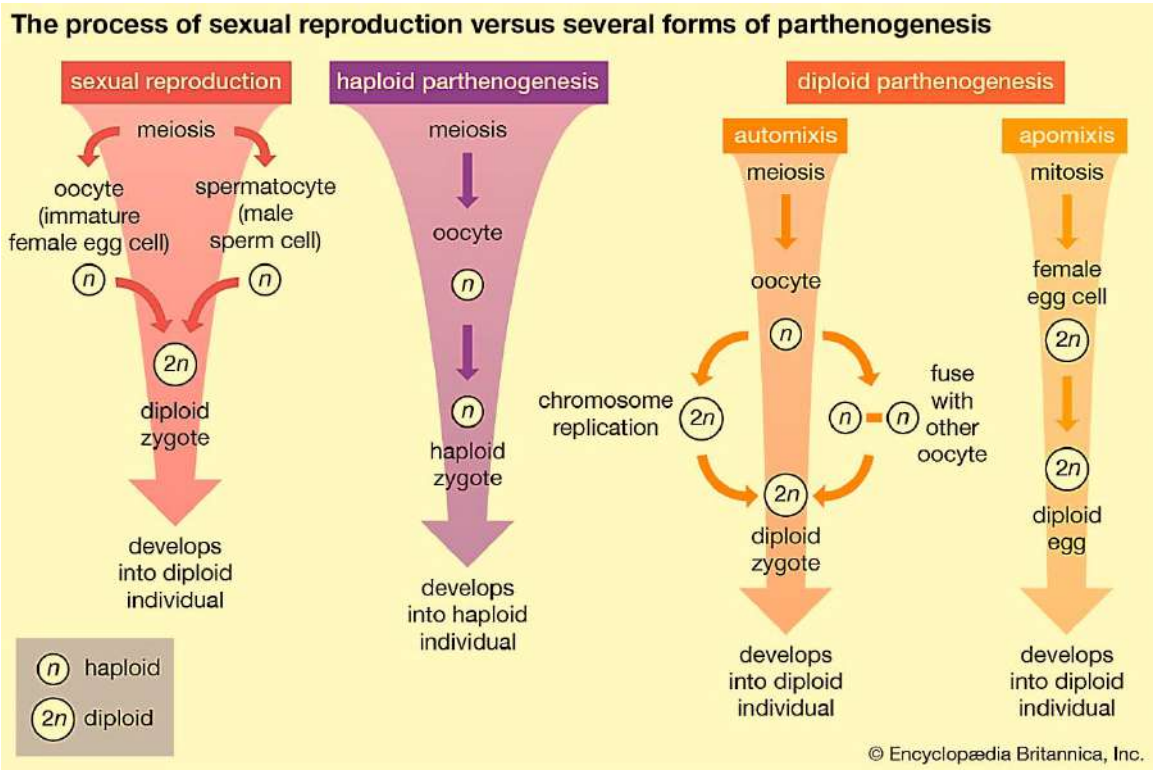
    i. **Complete or obligatory parthenogenesis:** When the organisms are exclusively dependent on the parthenogenesis for their reproduction. The condition is called

as complete parthenogenesis or obligatory parthenogenesis. This condition can be obsewrved in certain insects which have no sexual phase and no males, and is mainly found in invasive insect species, such as aphids (*Aphis sps*) and willow sawfly (*Nematus oligopilus*). Complete parthenogenesis allows a population to multiply and invade more rapidly from a very small and sparse population, potentially up to twice as fast.

ii. **Incomplete or facultative parthenogenesis:** The life cycle of some of insects possess two generations, the sexual generation and asexual or parthenogenetic generation. Both of generations alternate to each other. Therefore, this condition is called as incomplete parthenogenesis or facultative parthenogenesis or **cyclic parthenogenesis**. In this case, the diploid eggs produce females and the unfertilized eggs produce males.

Natural parthenogenesis is further classified into two based on the set of chromosomes that the progenies have, haploid or arrhenotokous parthenogenesis and diploid or thelytokous parthenogenesis.

1. **Haploid or arrhenotokous parthenogenesis:** In this condition, haploid eggs are not fertilized by the sperms and develop into the haploid individuals. *In this case, haploid individuals are always males and the diploid individuals are always females*. Arrhenotokous parthenogenesis is shown in some of the insects (Hymenoptera – bees and wasps, Homoptera – House fly, Coleoptera – Telephone pole beetle *Micromalthus debilis*, Thysanoptera – *Anthothrips verbasi*), arachnids, e.g., ticks, mites and certain spiders (*Pediculoides ventricusm*), and rotifers, e.g., *Asplanchne amphora*.



2. **Diploid or thelytokous parthenogenesis:** In this condition, the young individuals develop from the unfertilized diploid eggs. It may be of two kinds, ameiotic and meiotic parthenogenesis.

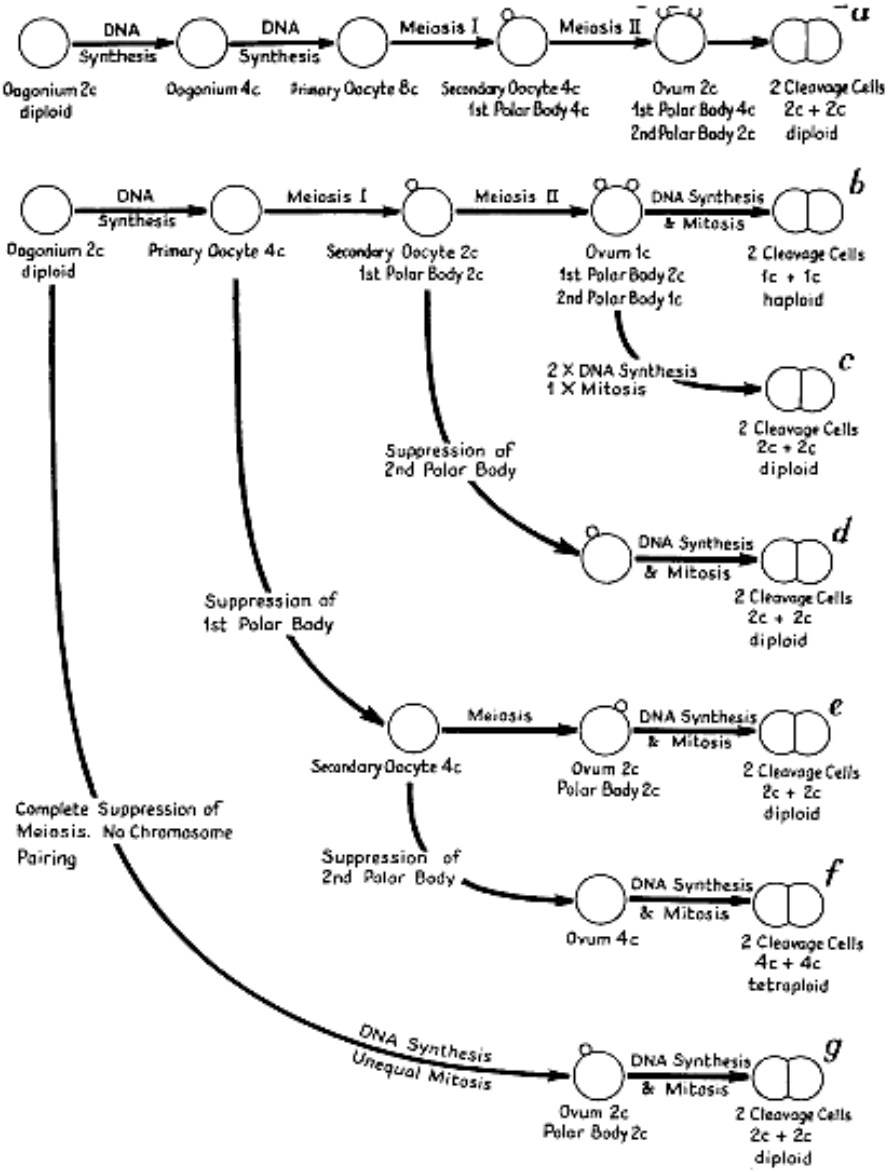


Fig. *Different routes of parthenogenesis in diploid females. (a) Premeiotic endoreduplication; (b) development of normally reduced egg; (c) postmeiotic endoreduplication; (d) suppression of 2nd polar body; (e) suppression of 1st polar body; (f) suppression of 1st and 2nd polar bodies; (g) ameiotic parthenogenesis. Additional routes are described in the text.*
The symbol c refers to the amount of DNA present in the chromosomes of a haploid cell before DNA synthesis. If parthenogenesis were to occur in a polyploid female, routes (a) and (g) would result in similarly polyploid daughters.

i. **Ameiotic parthenogenesi:** Development of an adult from an unfertilized diploid egg produced when first meiotic or reductional division does not occur but second meiotic division occurs as usual. The development of individual from such egg is called as **ameiotic** or **apomictic parthenogenesis**. This type of

parthenogenesis occurs in *Trichoniscus* (Isopoda), *Daphnia pulex* (Crustacea), *Campelona rufum* (Mollusca), weevils and long horned grasshoppers.

ii. Meiotic arthenogenesis: Certain eggs develop by the usual process of oogenesis but at certain stages diplosis or doubling of chromosome number and production of diploid eggs occur. Such eggs develop into the diploid individuals and this phenomenon is known as the meiotic parthenogenesis. The diplosis of the dipoid thelytoky may occur by the following methods:

By autofertilization: In certain cases, the oocye divides meiotically up to the formation of ootid or ovum and secondary polocyte. But the ootid and secondary polocyte unite together to form as dipoid egg which develops into a new individual, e.g., *Artemia salina* (Crustacea) and various other organisms.

By restitution: Sometimes in primary oocyte, karyokinesis forms a nucleus of the secondary oocyte and nucleus of the first polocyte. But the karyokinesis is not followed by the cytokinesis. The chromosomes of both daughter nuclei are arranged on the equator and undergo second meiotic division to form a diploid ootid and a diploid polocyte. The diploid ootid develops into a diploid individual. Such type of diplosis is found in insects of order Hymenoptera (*Nemertis conesceus*).

2. **Artificial parthenogenesis:** The parthenogenesis that occurs under certain artificial conditions is known as artificial parthenogenesis, i.e. the parthenogenesis induced in the artificial controlled environment is known as artificial parthenogenesis. The artificial parthenogenesis may be induced by various chemical and physical means in the eggs of most echinoderms, molluscs, annelids, amphibians, birds and mammals..

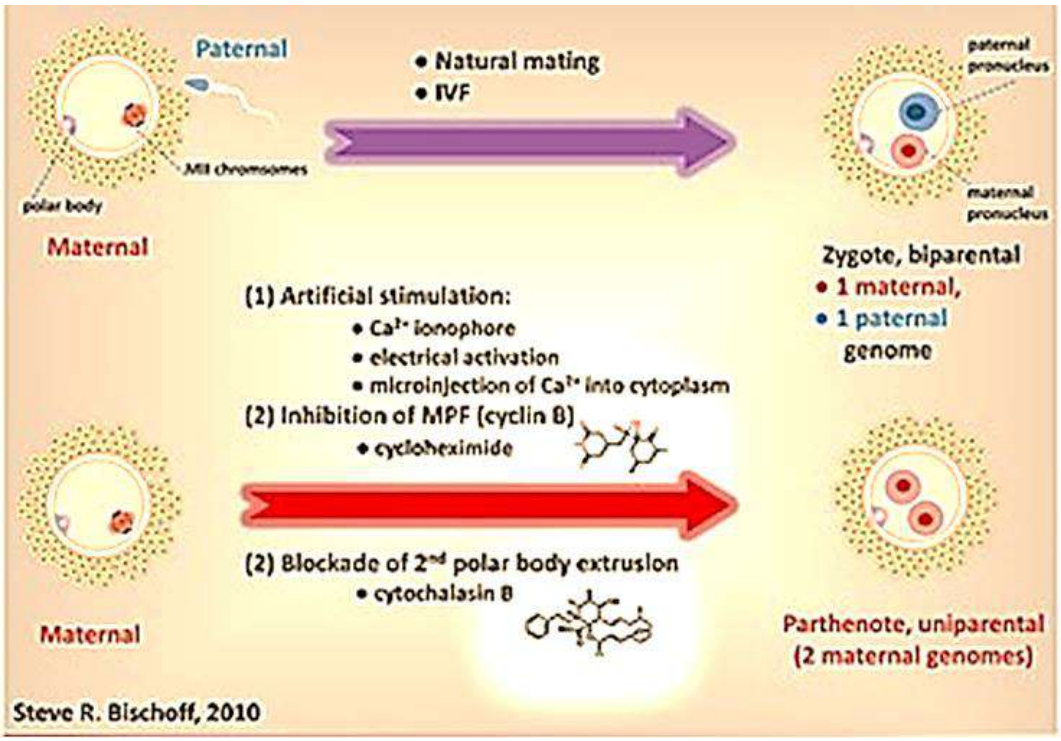
   i. **Physical means:** The following physical means cause the parthenogenesis:

   - **Temperature:** Sudden change in temperature can cause parthenogenesis, such as when an egg is transferred from the 30°C to 0 - 10°C, the parthenogenesis is induced.
   - **Electrical shocks:** It can also lead to parthenogenesis.
   - **UV light:** Ultraviolet light can also cause parthenogenesis.
   - **Pricking:** When the eggs are pricked by the fine glass needles, the development of young ones takes place parthenogenestcally.

   ii. **Chemical means:** The following chemical have been found to induce parthenogenesis in the normal eggs:

   - **Chloroform;**
   - **Strychuine;**
   - **Hypertonic and hypotonic sea waters;**
   - **Chlorides** of K^+, Ca^{++}, Na^+, Mg^{++}, etc.;
   - **Acids** such as butyric acid, lactic acid, oleic acid and other fatty acids;
   - **Fat solvents**, e.g., toluene, alcohol, benzene and acetone;

- **Urea and sucrose.**



Significance of parthenogenesis

- The parthenogenesis serves as the means for the determination of sex in the honey bees, wasps, etc.
- The parthenogenesis supports the chromosome theory of inheritance.
- It is the most simple, stable and easy process of reproduction.
- It eliminates the variation from the populations.
- It is the best way of high rate of multiplication in certain insects, e.g., aphids.
- It causes the polyploidy in the organisms.
- It encourages the development of the advantageous mutant characters.
- It checks the non-adaptive combination of genes which may be caused due to the mutation.
- It eliminates the wastage of energy in the process of mating.
- It avoids the sterility in the races.

However, despite of several advantages, its main disadvantage is that individual produced by the parthenogenesis is not much successful in the struggle for existence due to absence of recombination in genetic material. Thus it lacks variation in the population.

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